第二章

2-1

解：高电压方面额定电压：

$$I_1 = S_N / \sqrt{3}u_1 = 500*10^3 /(\sqrt{3}*35000) = 8.25A$$

低电压方面额定电压：

$$I_2 = S_N / \sqrt{3}u_2 = 500*10^3 /(\sqrt{3}*400) = 721.7A$$

2-2 解：

（1）两个原边绕组串联，两个副边串联　K=10

原边额定电流 $I_{1N}$=10000/2200=4.545A

副边额定电流 $I_{2N}$=10000/220=45.45A

（2）两个原边绕组串联，两个副边并联　K=20

原边额定电流 $I_{1N}$=10000/2200=4.545A

副边额定电流 $I_{2N}$=10000/110=90.91A

（3）两个原边绕组并联，两个副边串联　K=5

原边额定电流 $I_{1N}$=10000/1100=9.09A

副边额定电流 $I_{2N}$=10000/220=45.45A

（4）两个原边绕组并联，两个副边串联　K=10

原边额定电流 $I_{1N}$=10000/1100=9.09A

副边额定电流 $I_{2N}$=10000/110=90.91A

2-3 解：

(1)$I_{1Nl}$ =$S_N$/$\sqrt{3}$ $U_{1N}$=28.87A　$I_{1N\Phi}$= $I_{1Nl}$/$\sqrt{3}$ =16.67A

$I_{1N2}$ =$S_N$/$\sqrt{3}$ $U_{2N}$=5*$10^5$/$\sqrt{3}$ *400=721.69A

(2) k= $U_{1N}$/ $U_{2N}$=$N_1$/$N_2$　$\sqrt{3}$ *1000/400=960/$N_2$

∴$N_2$=22　E= $U_{2N\Phi}$/N=400/22$\sqrt{3}$ =10.5V

(3) $E_1 = \sqrt{2}\pi f N_1 \phi_m = \sqrt{2}\pi f N_1 B_m s$ $E_1 = \sqrt{2}\pi f N_1 \phi_m = \sqrt{2}\pi f N_1 B_m S$

∴S=$10^4$/($\sqrt{2}\pi$ *50*1. 4*960)=335 ㎝ $^2$

(4) $S_1$= $I_{1N\Phi}$/3=16. 67/3=5. 56 ㎜ $^2$　$S_2$= $I_{2N\Phi}$/3=721. 69/3=240. 6 ㎜ $^2$

2-5

解：$I_{1N} = S_N / U_{1N} = 10000/2200 = 4.55A, I_{2N} = 45.5A$

$$r_{1*} = r_1 \frac{I_{1N}}{U_{1N}} = 3.6*4.55/2200 = 0.00744$$

，

$$r_{2*}=r_2\frac{I_{2N}}{U_{2N}}=0.036*45.5/220=0.00744$$

$$r_m=P_{Fe}/I_m^{\ 2}=P_{Fe}/I_0=1352.49 \qquad r_{m*}=r_m\frac{I_{1N}}{U_{1N}}=2.79$$

$$X_k=X_1+X_2'=26.2 \quad \text{假设} \quad X_1=X_2'$$

$$X_{1*}=13*4.55/2200=0.0269, X_{2*}=X_2'=4.55/2200=0.0269$$

$$Z_m=\frac{U_m}{I_m}=9670.33\Omega$$

$$X_m=\sqrt{Z_m^{\ 2}-r_m^{\ 2}}=9575.28\Omega, \qquad X_{m*}=X_m\frac{I_m}{U_{1m}}=9575.28*4.55/2200=19.8\Omega$$

2-7

解：

(1)高压侧 $U_{1Nl}=10000V, U_{1N\varphi}=\frac{U_{1Nl}}{\sqrt{3}}=5773.5$

$$I_{1Nl}=I_{1N\varphi}=\frac{S_N}{U_{1Nl}\sqrt{3}}=103.92A \qquad Z_k=\frac{u_k^* U_{1N\varphi}}{I_k}=\frac{4.5\%*5773.5}{103.92}=2.5\Omega$$

$$r_k=\frac{P_{kN}}{3I_{N\varphi}^{\ 2}}=\frac{22000}{3*103.92^2}=0.679\Omega, X_k=\sqrt{Z_k^2-r_k^2}=2.41\Omega$$

$$I_{2Nl}=I_{2N\varphi}=\frac{S_N}{U_{2Nl}\sqrt{3}}=2598.08A$$

$$I_0=0.045I_{2N\varphi}=0.0458*2598.08=116.91A$$

$$k=\frac{U_{1N\varphi}}{U_{2N\varphi}}=25$$

折算到一次侧的励磁电阻和励磁电抗及励磁阻抗如下：

$$r_m=k^2*\frac{P_0}{3I_0^{\ 2}}=103.65\Omega, Z_m=k^2*\frac{U_0}{I_0}=k^2*\frac{U_{2N\varphi}}{I_0}=1234.6\Omega, X_m=1230.24\Omega$$

利用近似等效电路进行计算：

$\dot{I}_2' = \dot{I}_m - \dot{I}_1 = \frac{5773.5}{103.65 + j1230.24}$-103.92(0.8-$j$0.6)=100.87∠145.11°　，归算前的 $I_2$=25$I_{1N}$=2521.75A

$\dot{U}_2' = \dot{U}_1 - \dot{I}_2' Z_k = \dot{U}_1 - \dot{I}_2'(r_k + jX_k) = 5773.5\angle 0^\circ - \dot{I}_2'(r_k + jX_k) = 5580\angle -1.64^\circ$ ，归算前的 $U_2$=223.2V

(2) 由前面的计算值求电压变化率为：$\Delta U\% = (1 - U_{2*}) * 100\% = 3.35\%$

由公式近似求电压变化率为：

$$\Delta U\% = (r_{k*}\cos\theta_2 + X_{k*}\sin\theta_2) * 100\% = (0.012 * 0.836 + 0.043 * 0.549)100\% = 3.36\%$$

$$\theta_2 = -1.64° - (-34.92°) = 33.28°$$

2-8

解：高压侧 Y 连接额定线电压 $U_{1Nl} = 6300V$，额定相电压 $U_{1N\varphi} = 3637.31V$

$$I_{1N\varphi} = I_{1Nl} = \frac{S_N}{\sqrt{3}U_{1N}} = 29.326A$$

低压侧 $U_{2N\varphi} = U_{2Nl} = 400V$，$I_{2Nl} = 461.89A$，$I_{2N\varphi} = \frac{I_{2Nl}}{\sqrt{3}}$

空载时低压侧 $I_{20l} = 27.7A$　$I_{20\varphi} = \frac{I_{20l}}{\sqrt{3}} = 15.993A$

激磁阻抗：$r_m = \frac{p_0}{3I_{20\varphi}^2} = 1.89\Omega, Z_m = \frac{U_{2N\varphi}}{I_{20\varphi}} = 25.01\Omega, X_m = 24.94\Omega$

低压侧阻抗基值：$Z_{2b} = \frac{u_{2N\varphi}}{I_{2N\varphi}} = 1.5\Omega$

$r_{m*} = r_m / Z_{2b} = 1.26, X_{m*} = 24.94/1.5 = 16.63, Z_{m*} = 1.26 + j16.63$

短路实验高压：$Z_k = \frac{U_k}{\sqrt{3}I_k} = 5.596\Omega, r_k = \frac{P_k}{3I_k^2} = 2.213\Omega, X_k = 5.14\Omega$

高压侧阻抗基值：$Z_{1b}=\dfrac{u_{1N\varphi}}{I_{1N\varphi}}=124.03\Omega$

$r_{k*}=r_k/Z_{1b}=0.0178, X_{k*}=0.0414, Z_{k*}=0.0178+j0.0414$

(3) $r_L=\dfrac{U_L}{I_L}=\dfrac{400/\sqrt{3}}{461.89}=0.5\Omega$

2-9

(1) 第一步，计算高压侧和低压侧的额定相电压和额定相电流。

高压侧 Y 连接额定线电压$U_{1Nl}=110000V$，额定相电压$U_{1N\varphi}=63508.53V$

$I_{1N\varphi}=I_{1Nl}=\dfrac{S_N}{\sqrt{3}U_{1N}}=656.09A$

低压侧 $U_{2N\varphi}=U_{2Nl}=11000V$， $I_{2Nl}=6560.99A$， $I_{2N\varphi}=\dfrac{I_{2Nl}}{\sqrt{3}}=3788.10A$

空载时低压侧 $I_{20l}=0.02I_{2Nl}=131.22A$ $I_{20\varphi}=\dfrac{I_{20l}}{\sqrt{3}}=75.76A$

激磁阻抗：$r_m=\dfrac{p_0}{3I_{20\varphi}^2}=7.72\Omega, Z_m=\dfrac{U_{2N\varphi}}{I_{20\varphi}}=145.19\Omega, X_m=144.98\Omega$

低压侧阻抗基值：$Z_{2b}=\dfrac{u_{2N\varphi}}{I_{2N\varphi}}=2.90\Omega$

$r_{m*}=r_m/Z_{2b}=2.66, X_{m*}=144.98/2.90=49.93, Z_{m*}=2.66+j49.93$

短路实验高压：$Z_k=\dfrac{U_k}{\sqrt{3}I_k}=\dfrac{U_{k*}\times U_{INl}}{\sqrt{3}I_{INl}}=10.16\Omega, r_k=\dfrac{P_k}{3I_k{}^2}=0.46\Omega, X_k=10.15\Omega$

高压侧阻抗基值：$Z_{1b}=\dfrac{u_{1N\varphi}}{I_{1N\varphi}}=96.8\Omega$

$r_{k*}=r_k/Z_{1b}=0.0048, X_{k*}=0.1049, Z_{k*}=0.0048+j0.1049$

(2)

$$\dot{U}_{2*} = U_{2N*}\angle 0^\circ = 1 + j0$$

则 $\dot{I}_{2*} = \dot{I}_{2N*} \angle -36.87^\circ = 0.8 - j0.6$

$$\dot{U}_{1*} = \dot{U}_{2*} + \dot{I}_{2*}(r_{k*} + jx_{k*}) = 1 + (0.8 - j0.6) \times (0.0048 + j0.1049)$$
$$= 1.06678 + j0.08104 = 1.0699\angle 4.34^\circ$$

$$U_1 = 117.69\text{kV}$$

$$\dot{I}_{m*} = \frac{\dot{U}_{1*}}{Z_{m*}} = \frac{1.0699\angle 4.34^\circ}{2.66 + j49.93} = 0.0214\angle -82.61^\circ = 0.00275 - j0.212$$

$$\dot{I}_{1*} = \dot{I}_{m*} + \dot{I}_{2*} = 0.00275 - j0.0212 + 0.8 - j0.6 = 0.80275 - j0.6212 = 1.015\angle -37.73^\circ$$

$$I_1 = 1.015 \times 125000/(\sqrt{3} \times 110) = 665.92(A)$$

(3)按定义计算 $\Delta U = 6.99\%$， $\eta$=99.24%，

按公式计算 $\Delta U = 6.678\%$， $\eta$=99.27%

(4)最大效率是的负载系数 $\beta_m = 0.4708$，最大效率 $\eta_m$=99.44%